

International Comparison Program

[01.04]

Linking IRAN to the International Comparison Program 2011

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Preface

This paper describes Iran's participation in the 2011 round of the International Comparison Program as a singleton country. The Technical Advisory Group is invited to discuss and comment on the suggested approaches for linking Iran to the ICP.

Linking Iran to the International Comparison Program 2011¹

1. Background

Iran participated in the 2005 round of the International Comparison Program (ICP) under the coordination of the Asian Development Bank (ADB), without being a member country of the ADB. As the same arrangement was not possible for the 2011 ICP round, a special agreement was sought by the Global Office (GO) to link Iran to the ICP via another country or region. To this end, Turkey as a neighboring country to Iran was approached by the GO. Turkish Statistical Institute (TurkStat), National Coordinator for Turkey, accepted to be involved in a bilateral comparison aimed at linking Iran to the global results, while participating in the European Comparison Program (ECP).

2. Organizational Aspects

The GO is coordinating the linking exercise by working in partnership with the Central Bank of the Islamic Republic Iran (CBI) and TurkStat. As such, the GO is responsible for:

- Development of the linking approach;
- Overall project coordination;
- Meeting arrangements;
- Provision of survey materials (including item lists) and IT tools;
- Data validation; and
- Calculation of PPPs.

2.1. Meetings

To date, three operational meetings between the CBI, TurkStat and the GO have been held:

- 1st Meeting on 19-24 June, 2011 in Ankara, Turkey;
- 2nd Meeting on 24-26 October, 2011 in Ankara, Turkey; and
- 3rd Meeting on 26-29 April, 2012 in Ankara, Turkey.

The fourth meeting is scheduled for October, 2012. In addition one to two meetings are foreseen for 2013.

¹ This paper is prepared by Marko Rissanen, using input from Sergey Sergeev (2012): *Implementation of the Parallel Computations for Linking the Regions within the 2011 ICP*.

3. Linking Approach in Brief

The approach of linking Iran to the ICP 2011 includes three main elements as follows:

- For the Household Consumption Price Survey, Iran and Turkey are carrying out a bilateral comparison based on a common list of items priced by the both countries.
- For PPP data for Housing, Government Compensation, Machinery and Equipment, Construction, and Private Education, Iran follows the standard ICP methodology as defined by the GO.
- For National Accounts, Iran follows the standard ICP approach as defined by the GO.

Details of the suggested linking approaches are discussed in chapter 6 *Calculation of PPPs* below.

4. Household Consumption

4.1. Item List

The common item list for the linking exercise is based on the Eurostat list for Household Consumption. In Eurostat's rolling benchmark approach, Household Consumption price surveys are split into six surveys as presented in Table 1 below.

Table 1: ECP Surveys and item list availability

#	Code ²	Survey name	Item list available by
1	E10-1	House and Garden	End-March 2010
2	E10-2	Transport, Restaurants and Hotels	End-September 2010
3	E11-1	Services	End-March 2011
4	E11-2	Furniture and Health	End-September 2011
5	E12-1	Food, Beverages and Tobacco	End-March 2012
6	E12-2	Personal Appearance	End-September 2012

Each year two price surveys are conducted, hence two item lists are finalized. In total the HHC item list includes approximately 2000 items, of which around 300 are Global Core List (GCL) items. For the 2011 ICP round ECP surveys from 2010 to 2012 are used for computing the global PPPs.

The development of the common item list for linking exercise includes the following phases: i) *pre-survey by Iran*, to guarantee sufficient number of available items for each BH, and to identify any cases where important additional items are needed; ii) *GO analysis of the item list*, to identify any items that are "outdated" or otherwise problematic for linking; iii) *establishment of specifications* for additional items; and iv) *finalization of the item list* and other survey materials. Table 2 below gives number of

² The survey codes are referring to the survey in French, enquête, (E), survey year (2010, 2011 or 2012) and order of the given survey in the given year (1 or 2).

items included in the common list. Figures for the final ECP survey, *E12-2 Personal Appearance*, are not yet available.

Table 2: Number of ECP and additional items included in the common list

#	Code	Survey name	# ECP items	# Additional Items	Total
1	E10-1	House and Garden	296	18	314
2	E10-2	Transport, Restaurants and Hotels	174	8	182
3	E11-1	Services	170	0	170
4	E11-2	Furniture and Health	341	0	341
5	E12-1	Food, Beverages and Tobacco	319	1	320
6	E12-2	Personal Appearance	N/A	N/A	N/A
		Total	1300	27	1327

4.2. Price Surveys

For Turkey, prices collected for the ECP exercise will be used for the linking, and in addition prices will be collected for the limited number of items introduced solely for the linking purposes. Price collections follow the ECP schedule, as shown in Table 3 below. Prices are collected once for each ECP survey, in the second quarter for the first survey of the year, and in the fourth quarter for the second survey of the year. Annual average prices are derived from survey level prices using Temporal Adjustment Factors (TAFs)³. Following an agreement with TurkStat, Eurostat is submitting the Turkish price data to the GO.

For Iran, price collections are initialized as soon as the item lists are available for the given survey. As with the other ICP regions, the objective is to collect prices for four quarters, or when this is not possible, cover as many quarters as possible. This means that for the E10-1, E10-2, E11-1 and E11-2 surveys prices are collected in four quarters, for E12-1 survey in two quarters, and E12-2 in one quarter, as shown in Table 3 below.

Table 3: Price collection schedule for Turkey (TR) and Iran (IR)

#	Code	Survey name	2010			2011				2012			
			Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	E10-1	House and Garden	TR					IR	IR	IR	IR		
2	E10-2	Transport, Restaurants and Hotels			TR			IR	IR	IR	IR		
3	E11-1	Services				TR	IR	IR	IR	IR			
4	E11-2	Furniture and Health						TR	IR	IR	IR	IR	IR
5	E12-1	Food, Beverages and Tobacco								TR	IR	IR	
6	E12-2	Personal Appearance										IR	TR

³ ECP countries are required to provide Eurostat with monthly temporal adjustment factors with which the national survey prices can be converted to national annual prices. The adjustment factors are to be monthly and to be transmitted once a year. (Eurostat-OECD PPP Manual, European Communities / OECD, 2006.)

4.3. Survey Frame

In Turkey, prices are collected in 3 major cities (*Ankara, Istanbul and Izmir*). Spatial adjustment factors (SAFs)⁴ are used to adjust the survey level prices to reflect national average prices.

In Iran, the survey frame consists of 6 major cities (*Tehran, Mashhad, Esfahān, Tabriz, Karaj and Shiraz*) and covers approximately 60 % of urban area total population. The survey frame does not include rural locations.

For both countries, survey frame overlaps with the Consumer Price Index (CPI) frame, which is essential when temporal adjustment of prices is carried out.

4.4. Price Validation

As for any other ICP country, Iranian prices and metadata, including importance indicators, are validated first at the country level during intra-country validation, subsequently at the regional level during inter-country validation, and finally at the global level against prices provided by all ICP countries. The intra-country validation is conducted using the ICP-Kit software, whilst the inter-country validation uses Quaranta Tables (QTs) generated by the GO. The QTs are calculated following the ECP BH classification⁵.

Regarding the inter-country validation, the GO proposed that a third country would be included in the validation in order to make it sounder and more effective. Following Eurostat's suggestion, Bulgaria, whose price and per capita GDP levels are similar to Turkey, was approached by the GO. National Statistical Institute of Bulgaria accepted to join the validation process under strict confidentiality of their price data. As such, Bulgarian ECP price data is used exclusively for the price validation purposes, without being used in the linking of Iran to the ICP. Following an agreement with National Statistical Institute of Bulgaria, Eurostat submits the Bulgarian price data to the GO.

4.5. Adjustment of Prices and Calculation of Annual Averages

Survey level prices are adjusted for two purposes: i) price validation and ii) linking. For **price validation**, average national prices for Turkey and Bulgaria are CPI adjusted to overlap with Iran's survey periods. This is needed since prices for the three first ECP surveys are collected in 2010 and early 2011, whilst prices for Iran are collected starting from the Q3 of 2011, as shown in Table 4 above. Prices for the three remaining surveys do not need to be adjusted since the price collection periods overlap. Eurostat has conducted the temporal price adjustment for both countries.

⁴ After each survey all ECP countries are required to provide Eurostat with spatial adjustment factors in order to adjust average prices obtained from one or more locations within the economic territory of a participating country to national average prices. Countries report spatial adjustment factors, at least one for each basic heading included in the respective survey. (Eurostat-OECD PPP Manual, European Communities / OECD, 2006.)

⁵ ECP BH Classification differs from the ICP Classification.

Table 4: Adjustment of Turkish and Bulgarian prices for price validation purposes

#	Code	Survey name	Price Adjustment
1	E10-1	House and Garden	Adjusted to Q4'11
2	E10-2	Transport, Restaurants and Hotels	Adjusted to Q4'11
3	E11-1	Services	Adjusted to Q4'11
4	E11-2	Furniture and Health	No adjustment
5	E12-1	Food, Beverages and Tobacco	No adjustment
6	E12-2	Personal Appearance	No adjustment

For linking, Turkey's annual national average prices for the six ECP surveys (2010-2012) are adjusted to reflect the 2011 annual national average prices. The adjustment is done for all ECP countries in the process of linking the Eurostat countries in the ICP, thus the treatment of Turkey's prices does not differ from any other ECP country.

For Iran, survey prices are adjusted solely for linking purposes. In this process, validated quarterly average prices are backcasted to reflect the 2011 quarterly prices in order to calculate annual average prices for the ICP reference year 2011. Table 5 below gives the source quarter for each quarter of 2011. The CBI is responsible for all price adjustments.

Table 5: Adjustment of Iran's quarterly survey prices

#	Code	Survey Name	2011			
			Q1	Q2	Q3	Q4
1	E10-1	House and Garden	Q1'12	Q2'12	Current	Current
2	E10-2	Transport, Restaurants and Hotels	Q1'12	Q2'12	Current	Current
3	E11-1	Services	Q1'12	Q2'12	Current	Current
4	E11-2	Furniture and Health	Q1'12	Q2'12	Q3'12	Current
5	E12-1	Food, Beverages and Tobacco	?	?	Q3'12	Q4'12
6	E12-2	Personal Appearance	Q4'12	Q4'12	Q4'12	Q4'12

For the E12-1 survey the source quarters for Q1 and Q2 are yet to be decided.

4.6. Exchange Rate

Exchange rate of the Iranian Rial against the US Dollar underwent severe fluctuations in January 2012, as shown in Chart 1 below. The CBI has announced that it would be fixing the official rate of the Rial against the US Dollar at 12,260 Rials from 28th January 2012.

Chart 1: Reference Exchange Rates



The implications of exchange rate fluctuations will be discussed further with the CBI. One issue is that the exchange rate was changed in the middle of price collection period (Q1, 2012), which may have impact on the price of certain (imported) products. Also, agreement on the annual exchange rate for 2011 needs to be agreed made.

5. National Accounts and Special Surveys

Iran is reporting the National Accounts expenditure for the 155 ICP Basic Headings (BHs) using the Model Report on Expenditure Statistics (MORES) template.

For the Special PPP Surveys i.e., Housing, Government Compensation, Machinery and Equipment, Construction, and Education, Iran follows the standard ICP methodology as defined by the GO.

6. Calculation of PPPs

In calculation of PPPs for Iran, three aspects need to be considered:

- i) Calculation of Household Consumption BH PPPs;
- ii) Calculation of BH PPPs for the other GDP components; and
- iii) Aggregation of BH PPPs.

Regarding the calculation of PPPs for the “standard” ICP regions, the following approach is assumed at the BH level:

Step A1: Regional PPPs are calculated using both regional and Global Core List (GCL) items.

Step A2: All relevant GCL item prices provided by a country are divided by the regional Basic Heading PPP of the country, thus converting all GCL prices from the given region into a common regional numeraire.

Step A3: Converted prices resulting from Step A2 are processed through a single weighted CPD⁶ run including data from all regions, thus generating the *inter-regional linking factors* for the BH = inter-regional BH-PPPs, expressed as the Regional numeraires to the World numeraire.

Step A4: Fixity of regional PPPs in the World comparison is ensured by multiplying each country's regional basic heading PPP resulting from Step A1 by the inter-regional linking factor.

Further, it is assumed that the Country-Approach with Volume Redistribution (CAR-Volume)⁷ is used for linking at aggregated levels:

Step B1: All BH PPPs to the World numeraire and BH NA data from all countries are used to carry out unrestricted GEKS-Fisher aggregation above the basic heading level.

Step B2: Regional Volumes (real expenditure) totals are obtained by summing up volume from individual countries for each region, using the results from Step B1.

Step B3: The regional Volumes (real expenditure) totals from Step B2 are distributed among the countries in the regions according to country's volume shares in regional results to uphold regional fixity.

6.1. Linking at the BH Level

6.1.1. Household Consumption

Household Consumption BH PPPs for Iran are calculated through a bilateral Turkey - Iran comparison, in which Iran will be linked to the World through Turkish results in the World comparison. It is assumed that the annual average prices for Iran have been calculated as explained above in section 4.5, and that BH PPPs for Turkey in the World comparison are obtained as explained above in steps A1 to A4. After this, the following three steps are required:

Step C1: Reclassifying ECP items priced by Iran and Turkey to follow the ICP Classification⁸.

Step C2: Calculation of bilateral PPPs for Iran and Turkey on the basis of annual national prices in national currencies from Step C1 using weighted CPD method. Turkey's numeraire is 1 and Iran's PPPs relatively to Turkey are obtained from the CPD.

Step C3: Linking Iran's bilateral BH PPPs to the World comparison, using Turkey's BH PPPs in the World comparison as a bridge.

It should be noted that in this approach specific linking factors to the World numeraire are not calculated for Iran. Instead, Iran will be bridged to the World comparison, using the Turkish results in the

⁶ Annex 1 gives description of the weighted CPD method.

⁷ Annex 2 gives description of the CAR method.

⁸ ECP BH Classification differs from the ICP Classification. Due the reclassification, Iran may need to adjust classification of important items.

World comparison. Turkish results are derived following the “standard” approach described in steps A1 to A4 above.

6.1.2. Other GDP components

Regarding linking of Iran’s other GDP components, a number of possible approaches can be considered. These are described below.

1st Approach: Bilateral comparison “World – Iran”

This approach can be described as a two stage CPD procedure. During the **first stage**, the Global BH PPPs are obtained, as explained above in steps A1 to A4.

During the **second stage** the following steps are carried out:

Step D1: Recalculation of all countries’, excluding Iran, GCL item prices in national currency into the World numeraire, using the Global PPPs obtained in step A4.

Step D2: Calculation of average geometric prices for all GCL items, using prices derived from Step D1.

Step D3: Running weighted CPD for the two “Regions” – World and Iran – using average prices calculated in Step D2 and Iranian prices in national currency. World numeraire is 1 and Iranian PPP relatively Word numeraire will be obtained from the CPD.

This approached requires calculation of average prices for all GCL items in world numeraine for all countries in the world. If calculation of these averages is done using simple geometric mean, all countries have an equal weight. All former World PPPs are not changed due to this procedure, i.e., fixity is kept. The problematic point is the allocation of importance indicators for the GM World prices.

2nd Approach: Bilateral comparison “Set of selected countries - Iran”

The second approach is similar to the first one, but instead calculating average prices for GCL items based on all world countries’ prices, excluding Iran (Step D2), only the set of selected countries would be included. This allows selecting countries that are most important in the world comparison. However, as the selection will have an impact on Iran’s results, the countries have to be chosen carefully with sound arguments.

3rd Approach: Iran’s inclusion in the calculation of World PPPs

The third option is to include Iran in the calculation of the World’s PPPs, as any other country. The steps would then be as follows:

Step D1: Regional PPPs are calculated using both regional and Global Core List (GCL) items for the “Standard” ICP regions. No PPPs are calculated for Iran at this point.

Step D2: All relevant GCL item prices provided by a country are divided by the regional Basic Heading PPP of the country, thus converting all Global Core prices from the given region into a common regional numeraire. Again, for Iran no converting is done as there are no regional PPPs.

Step D3: Converted prices resulting from Step D2 are processed through a single weighted CPD run including data from all regions. For this step, Iran's prices in national currency are included, while prices for all other countries are included in Regional numeraires. This step generates the *inter-regional linking factors* for BHs = inter-regional BH-PPPs "Regional numeraires / World numeraire."

Step D4: The PPPs for Iran in World comparison are obtained from CPD run in Step D3, without applying any linking factors, which is done for all other countries (step A4 above).

This approach does not require any additional steps to be carried out solely for the purpose of linking Iran to the world comparison. Of course, the linking factors of the Regions are affected to some extent by inclusion of Iran's prices in the calculation⁹. However, the impact is expected to be very moderate (if the prices in regional numeraires of all countries, rather than Regional GM prices, are used) and its magnitude can be studied by running the calculations with and without Iran's prices.

4th Approach: Iran's inclusion in the Asia region

The fourth possible approach is to include Iran's prices in the Asian comparison for linking purposes. This would require calculating Asian results *with* and *without* inclusion of Iran's prices. When Iran's prices are included, the steps would be as follows:

Step D1: Calculation of regional PPPs for Asia, using prices for official Asian countries and Iran from regional and Global Core List (GCL) item lists.

Step D2: Dividing the GCL items prices by the regional BH PPP of the country, and thus converting all GCL prices into a common regional numeraire.

Step D3: Running a single weighted CPD including data from all regions, thus generating the *inter-regional linking factors* for the Basic Heading = inter-regional BH-PPPs "Regional numeraires / World numeraire."

Step D4: Multiplying Iran's regional BH PPPs resulting from Step D1 by the inter-regional linking factor, ensuring thus the fixity of regional Iran PPPs in the World comparison.

The final results for Asia would not include Iran's prices, but Iran's results would be derived from the Asian comparison. A benefit arising from this approach is that the 2011 results for Iran would be more comparable with the 2005 results than with the other approaches, due the fact that Iran participated in the Asian comparison in the previous round of the ICP.

⁹ However, this would also be the case if Iran were included in a Region.

6.2. Linking at the Aggregated Levels

Iran can be treated in the same way as all other countries in the World aggregation. Therefore, it is assumed that Iran has the same set of input data as all other countries for the aggregation:

- BH-PPPs (to a World numeraire); and
- BH expenditure in the standard ICP Classification.

The unrestricted GEKS is applied for all involved countries, including Iran. This enables obtaining Iranian Volumes (real expenditure) for the analytical categories, aggregates and GDP in the World numeraire. After this, following the agreed CAR-Volume approach, the Regional Volume Totals are redistributed within the Regions in accordance with the country's shares from the Regional comparisons. Iranian Volume is kept as it was obtained from the unrestricted GEKS.

7. Conclusion

The work on gathering and validating data for the linking exercise still continues. All price collections are expected to be concluded by the end of 2012. Data validation and compiling of 2011 National Account Expenditures will continue in 2013.

Annex 1: Weighted CPD¹⁰

Weighted CPD uses some explicit weights. Representative / important items receive some higher weight than non- representative / less important items. For example, the weights '2' and '1'; or 3 and 1; or some other appropriate weights can be used¹¹.

The unweighted original CPD derives estimators of regression parameters (1) through the minimization of the squares in logarithmic terms using a standard LSQ procedure

$$(1) \quad \sum_{i=1}^n \sum_{j=1}^r \sum_{l=1}^{c_j} [\ln(p_{ilj}) - \alpha'_j - \beta'_n - k']^2 \quad \text{with } \alpha'_1 = 0; \beta'_1 = 0$$

Representative / important items and non- representative / less important items receive the same weight '1' in the unweighted CPD.

The CPD weighted approach suggests that each price corresponding to a product in a given country in a region be given a prespecified weight in the least squares estimation. Suppose \mathbf{w} is a set of weights for representative / important (w^{repr}) and non-representative / less important ($w^{\text{non-repr}}$) items to be given to the price p_{ilj} , then the weighted least squares (WLS) approach applied to (1) can be presented as the following¹²:

$$(2) \quad \sum_{i=1}^n \sum_{j=1}^r \sum_{l=1}^{c_j} w [\ln(p_{ilj}) - \alpha'_j - \beta'_n - k']^2 \quad \text{with } \alpha'_1 = 0; \beta'_1 = 0$$

It is declared often that the advantage of the stochastic CPD approach is that it allows deriving standard errors for the CPD estimates of the purchasing power parities (PPPs), common prices, etc. However it is not easy to implement these standard errors in the analysis - there are numerous problematic points¹³.

¹⁰ Sergey Sergeev (2012): *Implementation of the Parallel Computations for Linking the Regions within the 2011 ICP*.

¹¹ **Note:** the weights "1" and "0" are applicable for the EKS* method (1 = for asterisked items *; 0 – for non-asterisked items) but not for the CPD method because the items with "0-weights" are non-priced items and they are eliminated from the calculations.

¹² See, D.S. Prasada Rao "The CPD method: a stochastic approach to the computation of PPP in the ICP," the SSHRC Conference on Index Numbers and Productivity Measurement, 30 June – 3 July, 2004, Vancouver
http://siteresources.worldbank.org/ICPINT/Resources/Country-Product-Dummy_Method.doc

¹³ It is unclear – How the stochastic estimations should be used practically:

- What are criteria for high / low standard errors?
- What one should do if standard errors are high but the results looks as plausible or vice versa?
- What should be done if the standard errors for PPPs are low but these are high for the international average prices?

Additionally, the estimations of errors depend on the regression specification

In effect, standard errors of the CPD parameters are not used in the ICP practice and respective indicators are not produced by the ICP-Kit explicitly.

Therefore, to make the CPD method more transparent and understandable for a broad array of users, the weighted CPD method is presented below in a more traditional index¹⁴ form specific to the GK method in geometric (logarithmic) terms¹⁵:

$$(3) \quad \pi_i = \left\{ \prod_{r=1}^R \prod_{j=1}^{N(r)} [P_{ijr} / PPP_r]^{q_{ijr}} \right\}^{1/\sum q_{ijr}}; \quad i = 1, 2, \dots, M$$

$$(4) \quad PPP_r = \left(\prod_{i=1}^M \prod_{j=1}^{N(r)} [P_{ijr} / \pi_i]^{q_{ijr}} \right)^{1/\sum q_{ijr}}; \quad r = 1, 2, \dots, N-1 \text{ (} PPP_R = 1 \text{)}$$

π_i is international average price of item i in the currency of the numeraire Region (in our case, Region R); π_i is an analogue of α_i from the CPD regression.

PPP_r is the PPP of Region r relative to the base region R ($PPP_R = 1$); PPP_r is an analogue of β_r from the CPD regression.

R – no. of Regions

¹⁴ Vice versa, it can be demonstrated that a number of widely used multilateral index numbers for PPPs can be derived using the stochastic approach. See, for example, D.S. Prasada Rao, G. Hajargasht "Stochastic Approach to Index Numbers for Multilateral Price Comparisons and their Standard Errors," WP06/2008, Centre for Efficiency and Productivity Analysis (CEPA), The University of Queensland, Brisbane, Australia, 2008

<http://www.uq.edu.au/economics/cepa/docs/WP/WP062008.pdf>

http://www.google.at/url?sa=t&source=web&cd=5&sqi=2&ved=0CEoQFjAE&url=http%3A%2F%2Fwww.ocs.fce.unsw.edu.au%2Ffce%2FResearch%2FResearchMicrosites%2FCAER%2FWorkshopPapers%2FEMG06%2FEMG06014.ppt&rct=j&q=prasada%20rao%20Geary%20Khamis%20stochastic&ei=AT9BTr3OIpDGswbBw6myBw&usq=AFQjCNEXkw5ez-JHzauxDr0PJTQDmA_P7w

This paper shows that price index numbers from commonly used methods like the G-K, the Ikle, the Rao-weighted and an additive multilateral system are all weighted least squares estimators of the parameters of the country-product-dummy (CPD) model.

The estimation of the parameters of the indices EKS type is described in the following papers by A. Deaton and O. Dupriez

http://www.princeton.edu/~deaton/downloads/deaton_dupriez_purchasing_power_parity_exchange_rates_global_poor_aeja_2011.pdf

http://www.princeton.edu/~deaton/downloads/Global_Poverty_and_Global_Price_Indexes.pdf

¹⁵ See E.Diewert "Weighted Country Product Dummy Variable Regressions and Index Number Formulae," http://siteresources.worldbank.org/ICPINT/Resources/product_dummy_variable.doc and S. Sergeev "The use of weights (indication of representativity) within the CPD and EKS methods at the basic heading level," http://siteresources.worldbank.org/ICPINT/Resources/Use_of_Weights.doc

$N(r)$ – no. of countries in the region r ,

M – no. of products within a BH

q_{ijr} are weights (imaginary quantities) for product i in country j from a region r ; the appropriate values can be **3** (for representative products) and **1** (for non-representative products).

$r \sum q_{ijr}$ is the cumulative value of representativity of item i among all countries in all Regions.

$i \sum q_{ijr}$ is the cumulative value of representativity of items priced in the country j / region r .

Average “International price” of the i th item (π_i) are presented as an ‘implicit quantity’-weighted geometric average of the PPP-adjusted national prices.

PPP for the j th region (PPP_j) are be presented as the geometric average (implicit weighted) deviation of its regional prices from the international prices

This system (3) (4) can be efficiently solved by an iterative method. GM of price ratios or simply exchange rates to a country selected as the base can be used as an initial set of unknown PPPs.

Each researcher can select the computational schema (regression technique or GK approach) in accordance with their own preferences and available tools. The final results should be the same in all versions independently on the concrete computational algorithm.

Annex 2: CAR method of linking above Basic Heading¹⁶

Input data sets to obtain the global aggregated results with regional fixity are the following:

- Country's NA data (the respective shares are used as weights)
- Global BH-PPPs (with fixity) and Regional BH-PPPs (to check the regional computations)
- Regional PPPs and VI /Country's shares in Regional Volumes for the aggregated headings

The Country Approach with Redistribution / Re-indexation (CAR) - Unrestricted EKS method – can be used for Volumes (CAR-Volumes) or for the PPPs (CAR-PPPs = Eurostat-OECD approach).

The Country-Approach with Volume Redistribution / Re-indexation (CAR-Volume) was adopted by the TAG ICP for linking above basic headings. All countries participate simultaneously in the Global calculation. Regional Volumes from the Global comparison are redistributed between the countries in accordance with the Regional Volume shares¹⁷. The main features:

- Each country is treated equally in the Global comparison
- Fixity of regional results is obtained by an indirect (two-stage) approach
- It is likely that the differences in the regional methodologies will have some lower impact on the (in)comparability of the World results with fixity

Any aggregated method can be used with this approach. **The GEKS (F) method was recommended by the TAG for the aggregation within the Regions well as for the Global comparison.**

All calculations by the GEKS method are carried out for each aggregated heading separately.

Firstly, the bilateral Fisher's PPPs¹⁸ for all pairs of the countries are calculated. At the second stage, all direct and indirect F-PPP (equally, all F-PPPs of a country j to all other countries) are averaged geometrically to obtain the transitive GEKS-PPPs.

F-PPP

$$P_F(p^k, p^j, q^k, q^j) \equiv [P_L(p^k, p^j, q^k, q^j) \cdot P_P(p^k, p^j, q^k, q^j)]^{1/2}$$
$$= \left[\left(\frac{p^j \cdot q^k}{p^k \cdot q^j} \right) \left(\frac{p^j \cdot q^j}{p^k \cdot q^j} \right) \right]^{1/2}$$

¹⁶ Sergey Sergeev (2012): *Implementation of the Parallel Computations for Linking the Regions within the 2011 ICP*.

¹⁷ The share of a country in the Volume-Total of a Region is nothing more than the Volume index "Country / Region." Therefore the redistribution can be presented also as the re-indexation.

¹⁸ The same can be applied to the Volume / Quantity indices because the F-index is symmetrical relatively variables (prices and quantities). The product of PPP(F) and Q(F) is the expenditure ratio.

In principle, each bilateral index (e.g., Tornqvist) can be used in the GEKS procedure. The Fisher indices, but not the Tornqvist indices, are used traditionally because the product of PPP(T) and Q(T) is not equal to the expenditure ratio.

GEKS-F

$$P^j \equiv \prod_{k=1}^K [P_F(p^k, p^j, q^k, q^j)]^{1/K}$$

$$Q^j \equiv p^j \cdot q^j / P^j$$

Countries within and across Regions can be very different. The bilateral indices for the countries with different price and quantity structures can be unreliable. In this aspect, the analysis of Laspeyres-Paasche Spreads (LPS) is very important. The selective EKS – direct F-indices with high LPS (e.g. higher than 1.5) and with PLS less than 1¹⁹ are replaced on the indirect indices via 3rd countries - should be investigated (at the least, experimental calculations should be done).

CAR-Volumes approach²⁰ was recommended as the official ICP 2011 method:

The unrestricted global GEKS-PPPs for the aggregates are used to recalculate the country's aggregates in national currencies into Volumes (real expenditure) measured in a world numeraire. Country's Volumes are summed up by the Regions and these Regional Volumes are redistributed in accordance with the country's shares in the Regional comparisons, to keep the regional fixity.

Volume “Country in the World” = Volume “Region in the World” x Share “Country / Region”

[Global Comparison]

[Regional Comparison]

This procedure can also be presented in the form of Volume indices

VI “Country / World” = VI “Region / World” x VI “Country / Region”

[Global Comparison]

[Regional Comparison]

The Volume indices (VI) “Region / World” and “Country / Region” can also be considered as the respective Volume shares.

The respective PPPs (with fixity) are calculated in an indirect way as:

PPP “National currency / World numeraire” = Nominal expenditure : Volume

¹⁹ In a “normal” case, Laspeyres index (arithmetic mean) is higher than Paasche index (harmonic mean).

²⁰ This method was described in Ch.15 of the ICP Manual as the calculation of the Regional scaling factors by the weighted harmonic mean.